

# Interference (and What Is Done about It)

Giovanni Vannucci

February 25, 2013



**Kaplan Breyer Schwarz & Ottesen, LLP**

Intellectual Property Attorneys

# Dimensions of Radio Signals

---

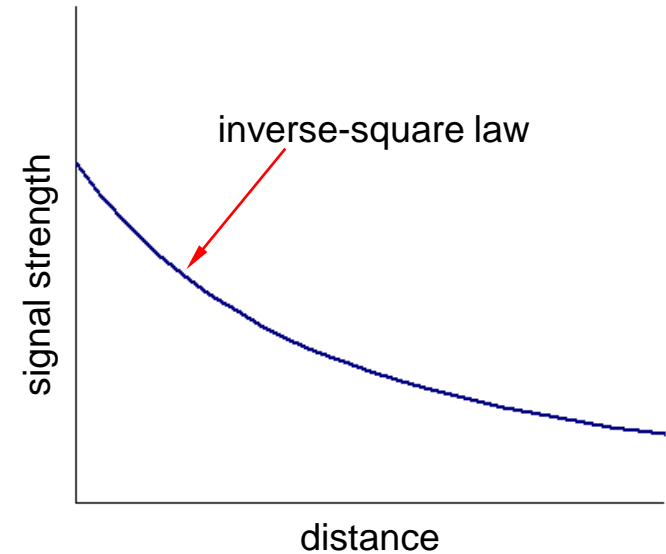
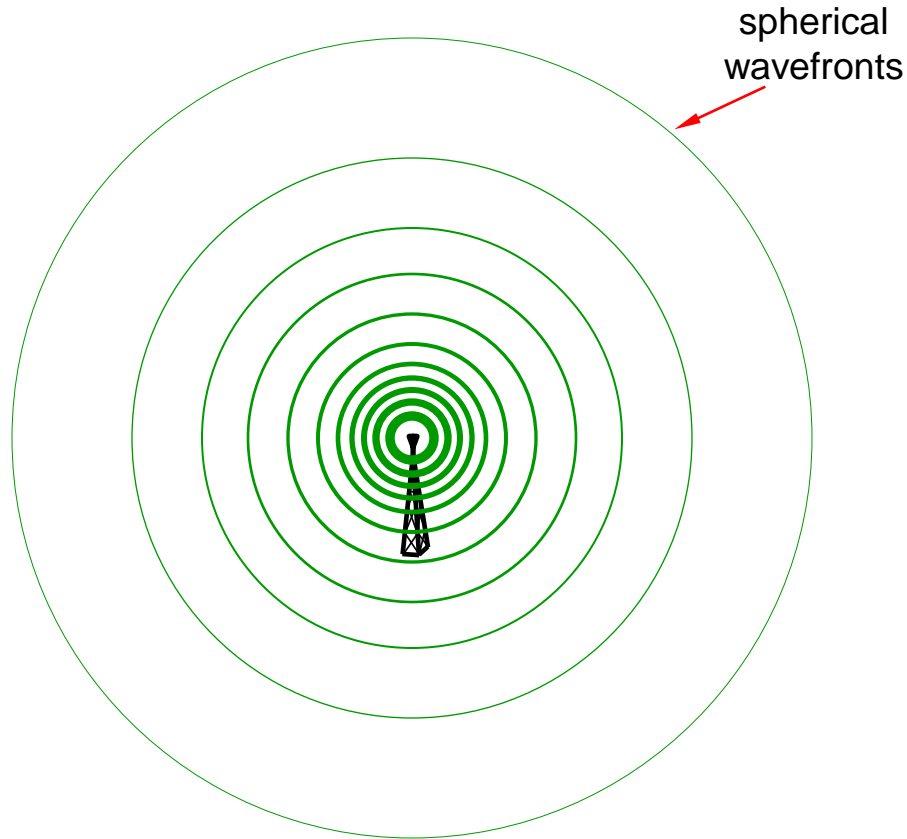
**Radio Signals exist  
in three “dimensions”**

***Space***

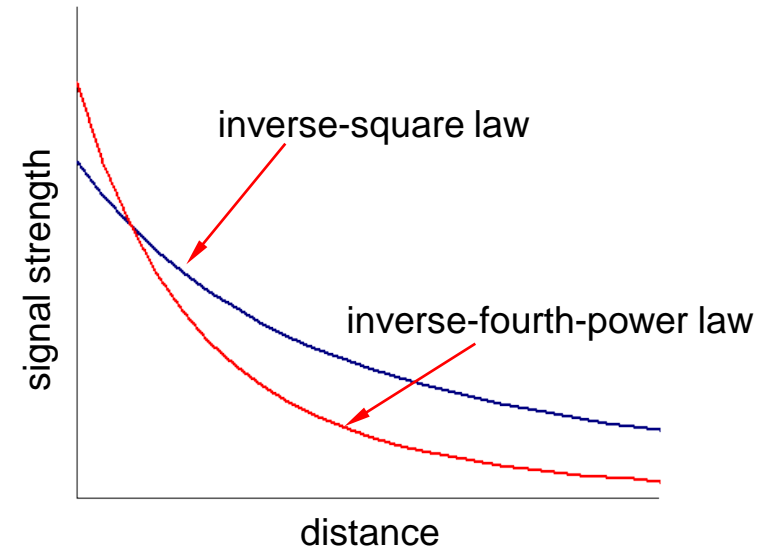
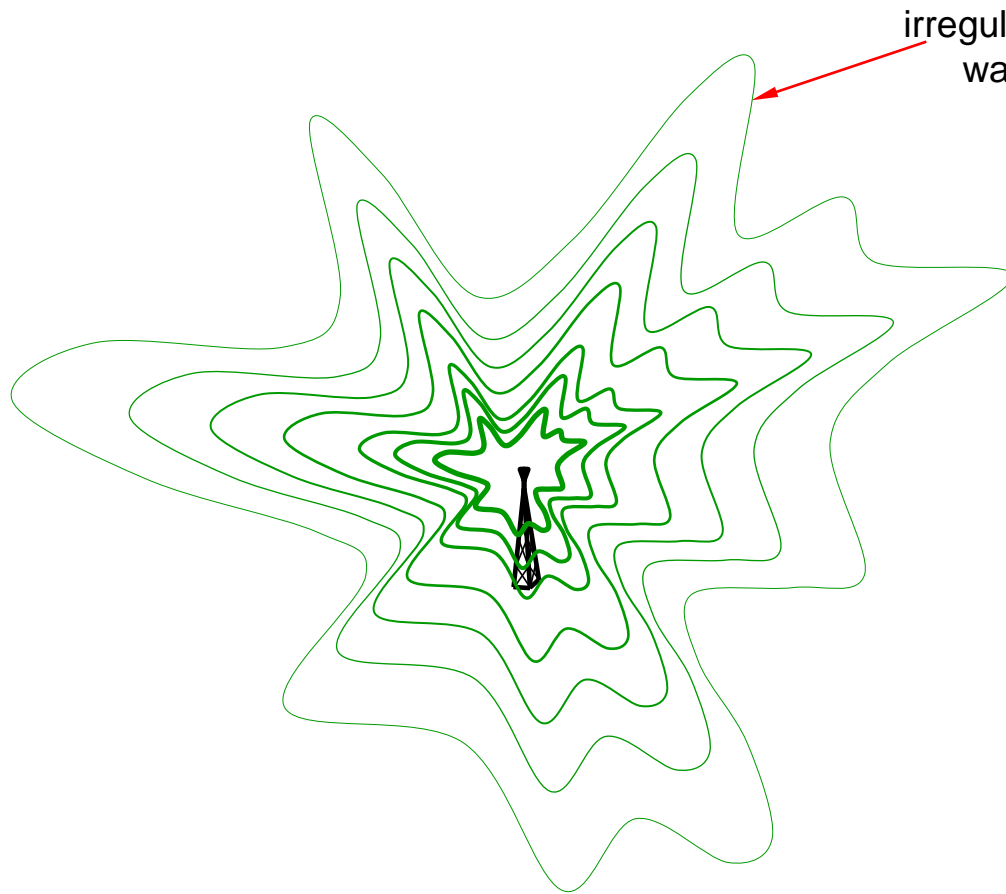
***Time***

***Frequency***

# Space – Idealized View of Radio Propagation



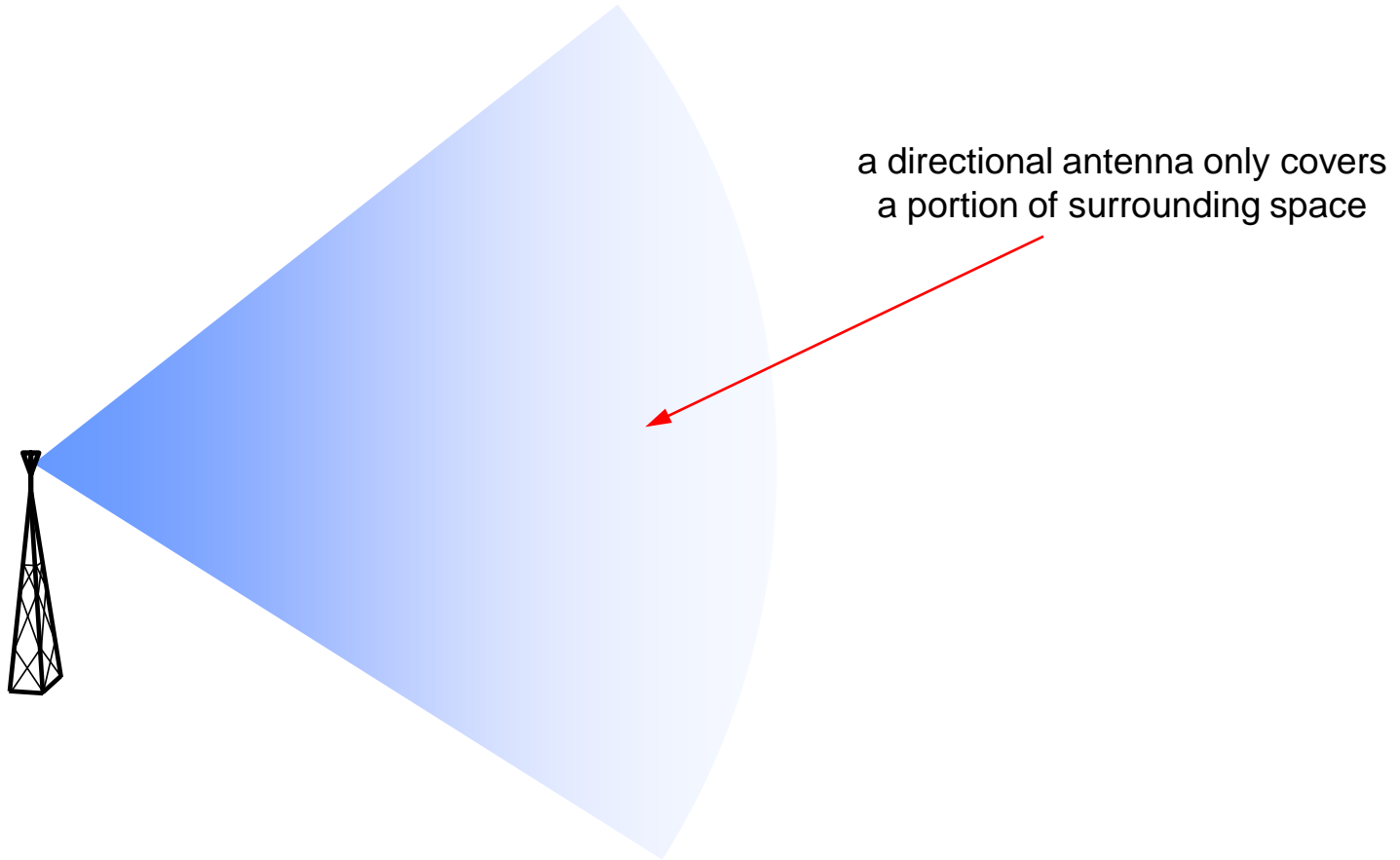
# Space – Real-World Radio Propagation



Many \$billions have been spent for good models of real-world radio propagation.

# Space – Directional Antennas

---

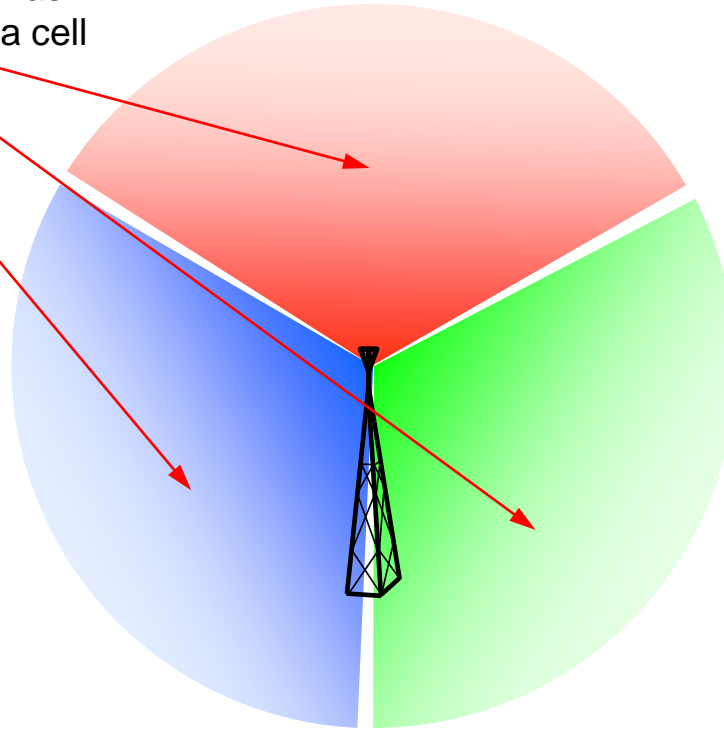


*Arrays, smart antennas, MIMO:  
provide even greater flexibility.*

# Space – Sectorization

---

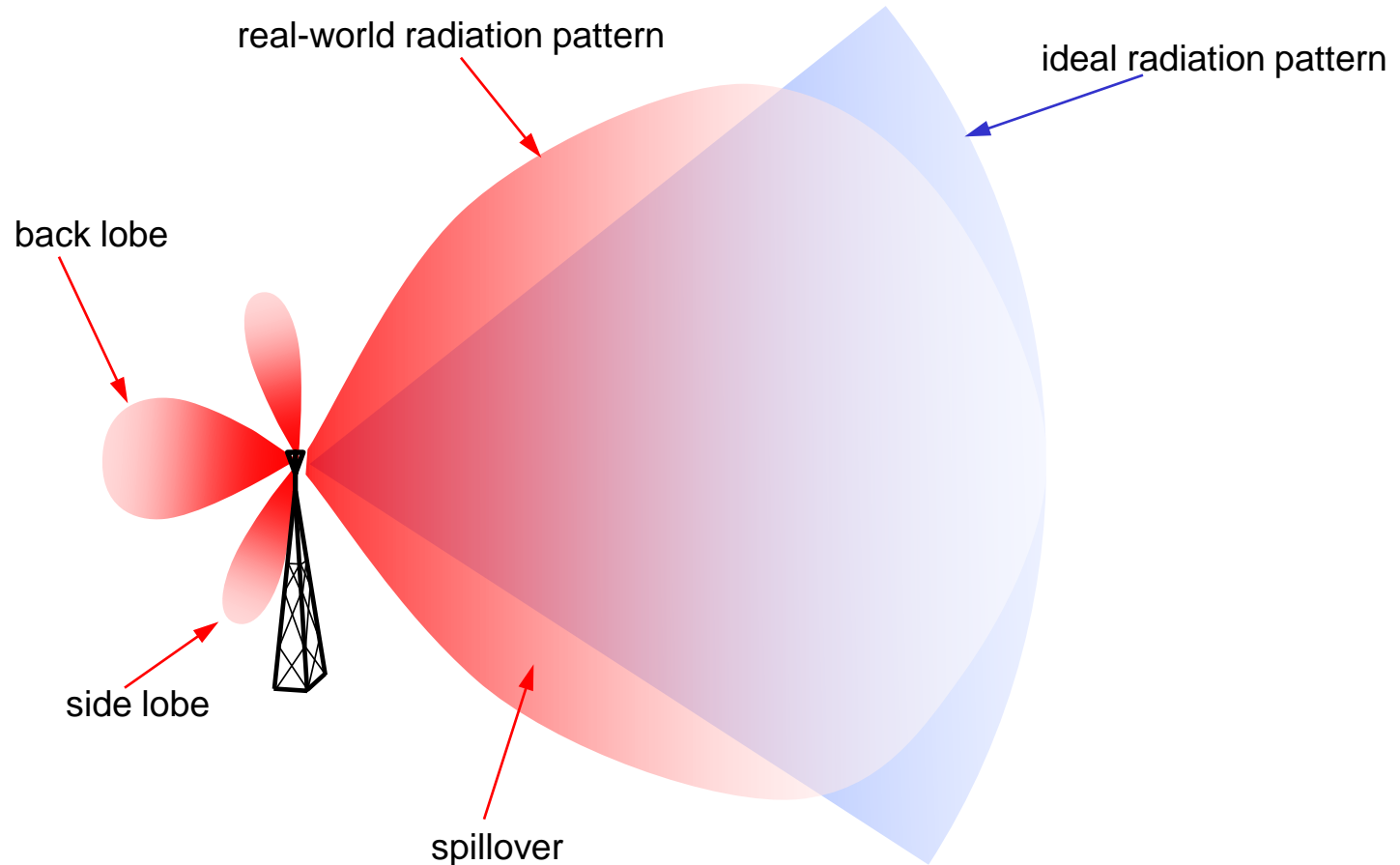
three directional antennas  
cover each one third of a cell



Antenna “downtilt” is also used.

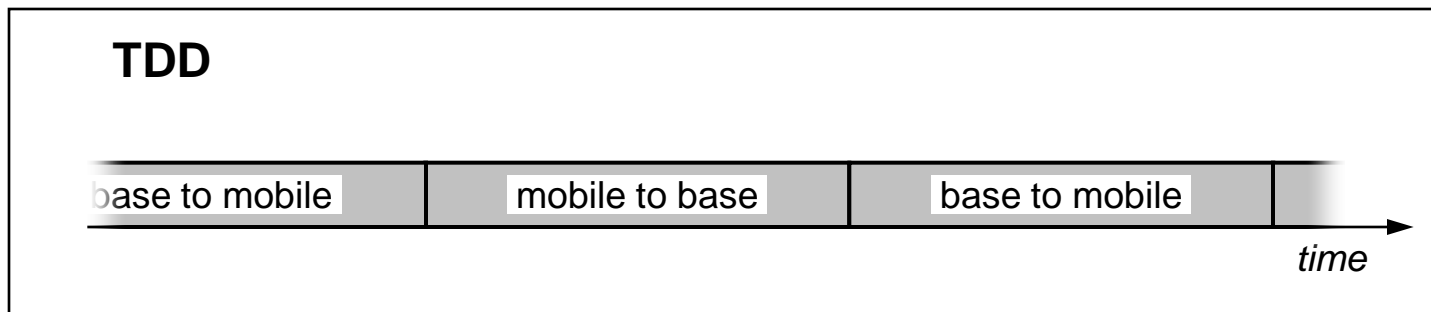
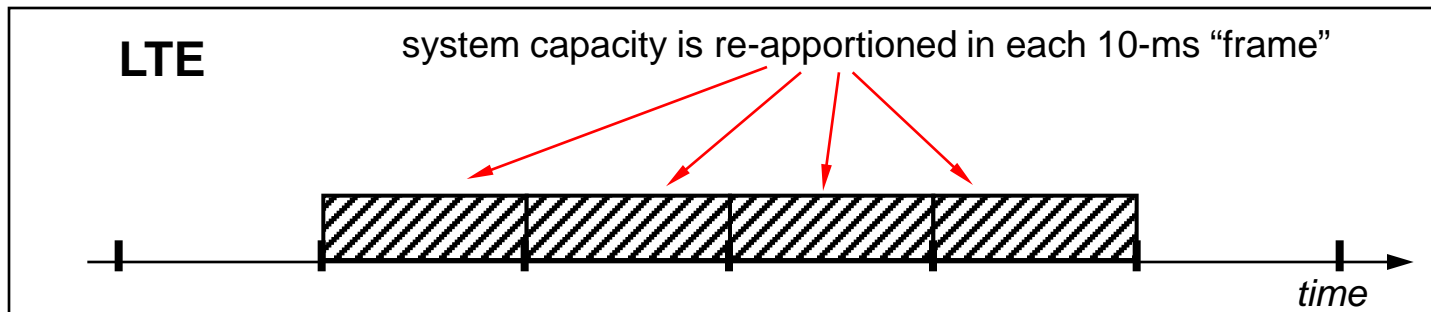
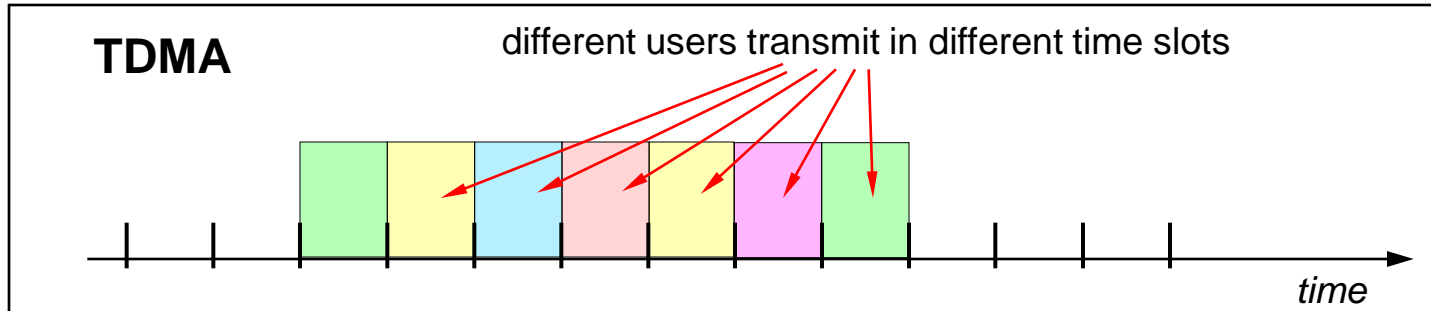
# Space – Real-World Directional Antenna

---



*Theory says:* a perfect directional antenna would be infinitely large.

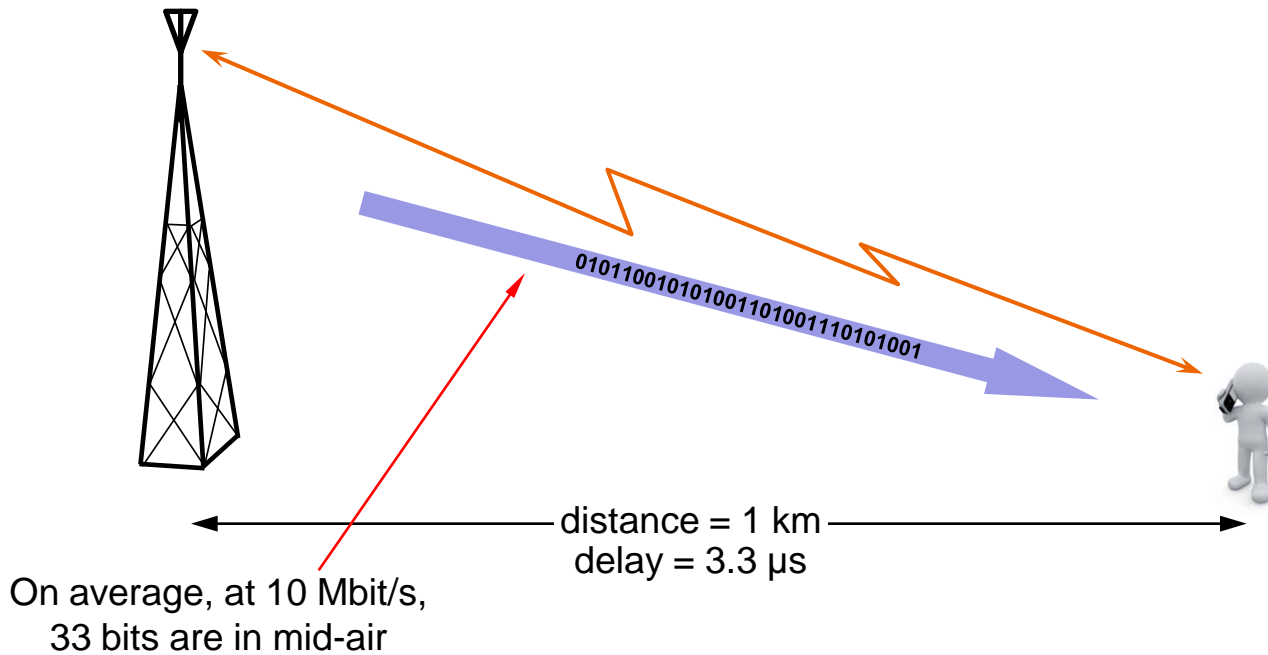
# Time – Time Is Used to Allocate Capacity





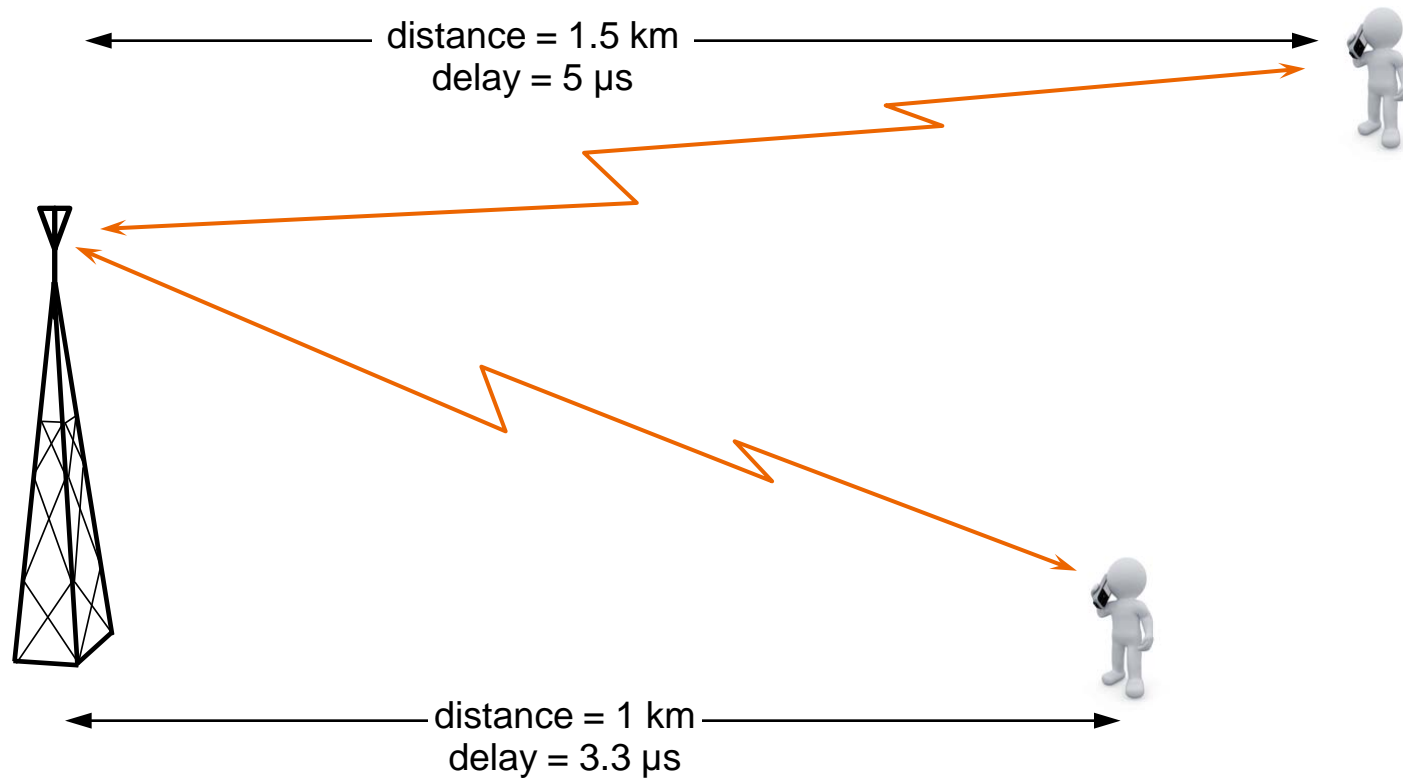
# Time – Real-World Propagation

---

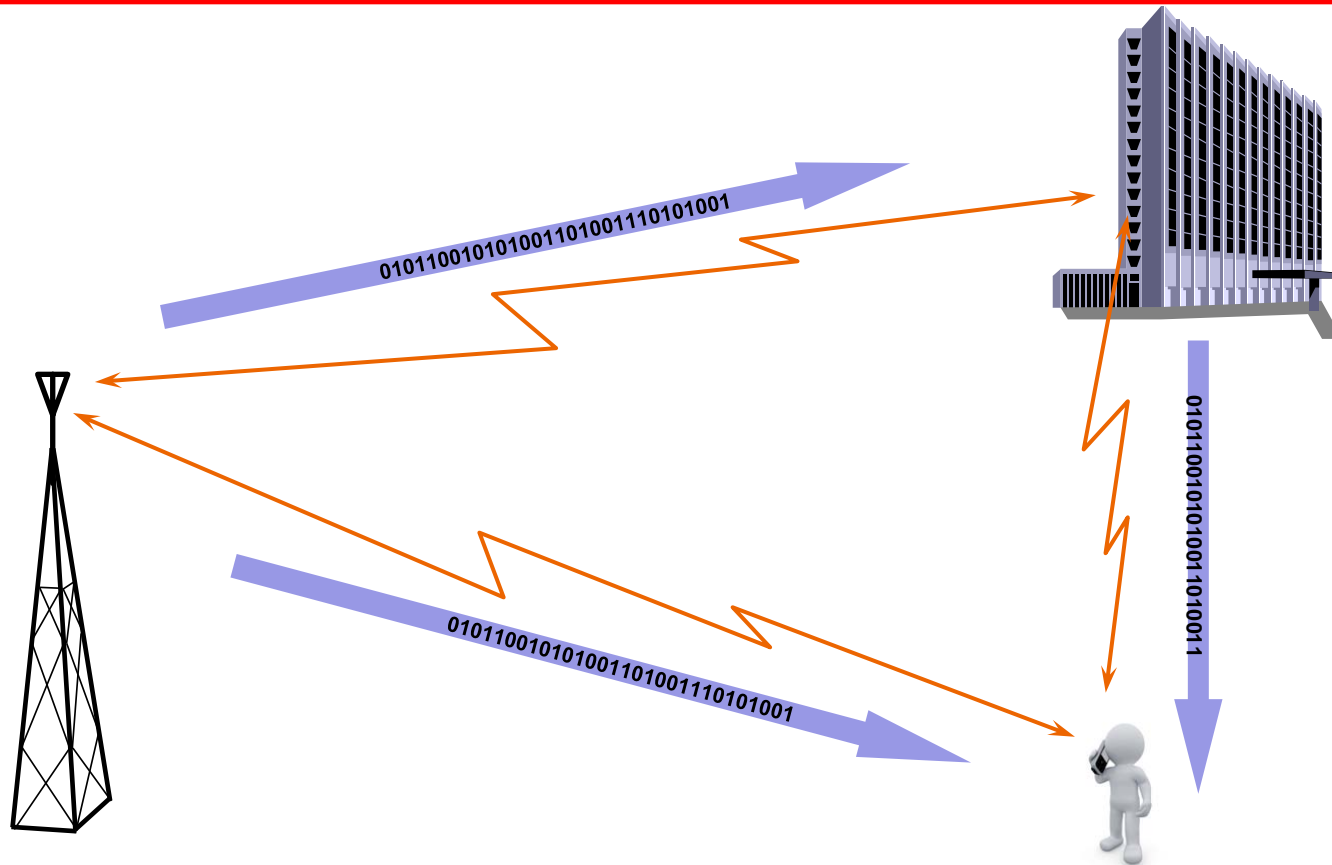


# Time – Real-World Propagation

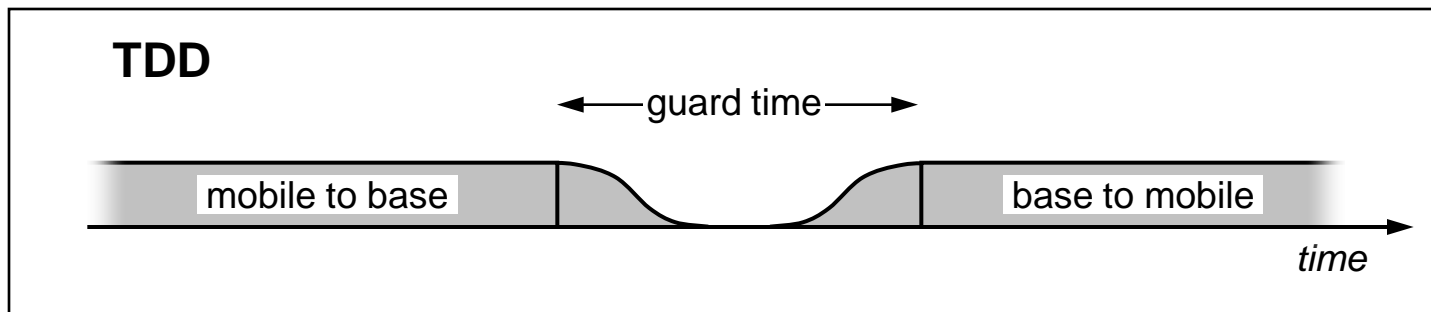
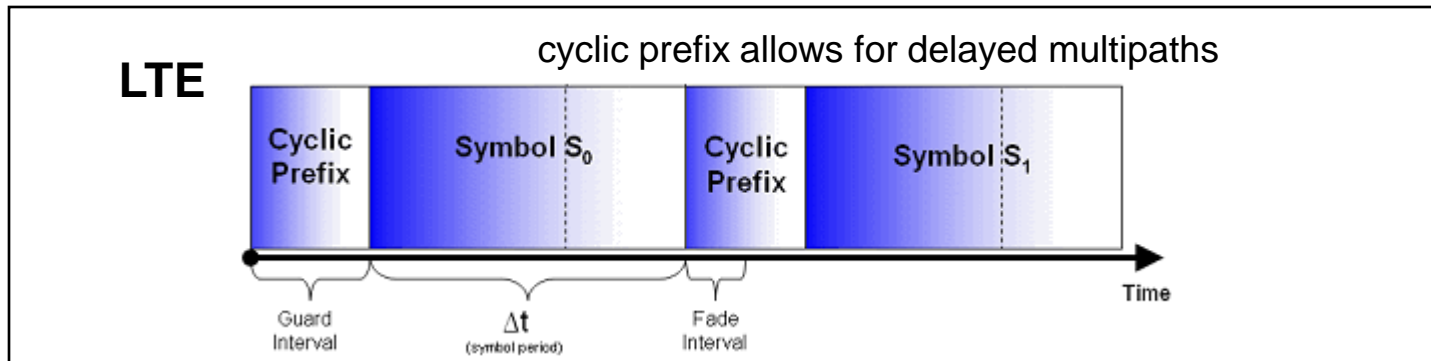
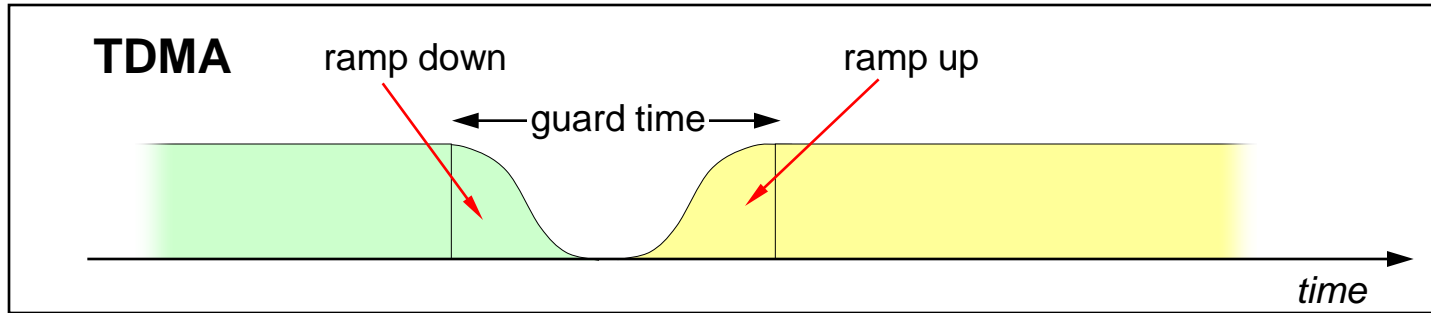
---



# Time – Real-World Multipath

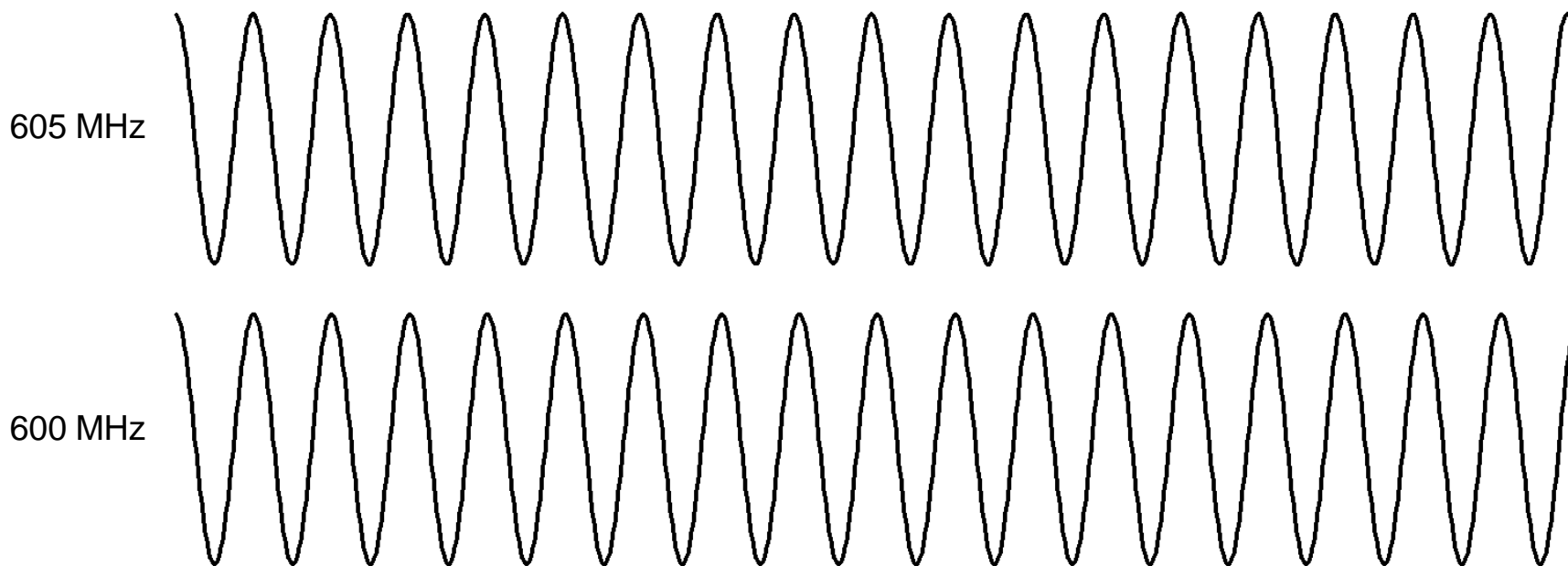


# Time – Guard Times



# Frequency – Orthogonality of Sinusoids

---

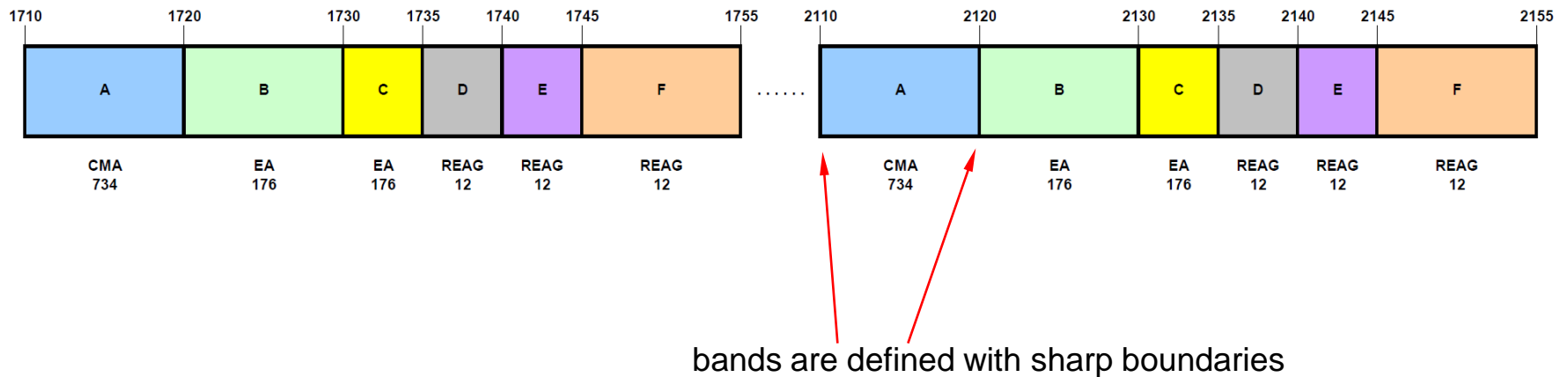


Sinusoidal signals of different frequencies are mutually “orthogonal”; *i.e.*, they can be detected independently without (theoretically) mutual interference.

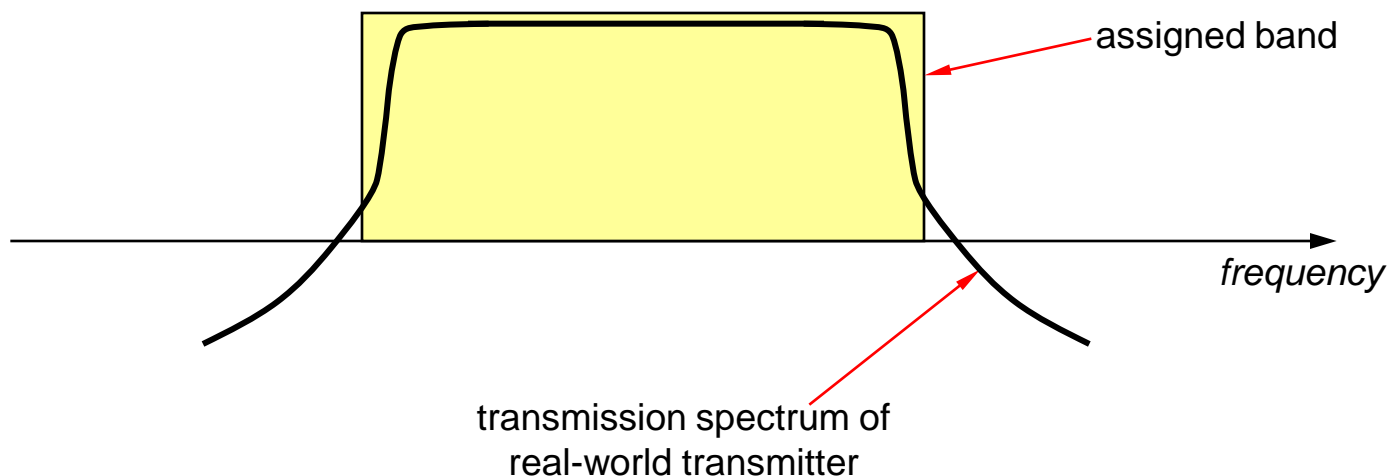
# Frequency – Frequency bands

---

## AWS Bands



# Frequency – Real-World Transmitters

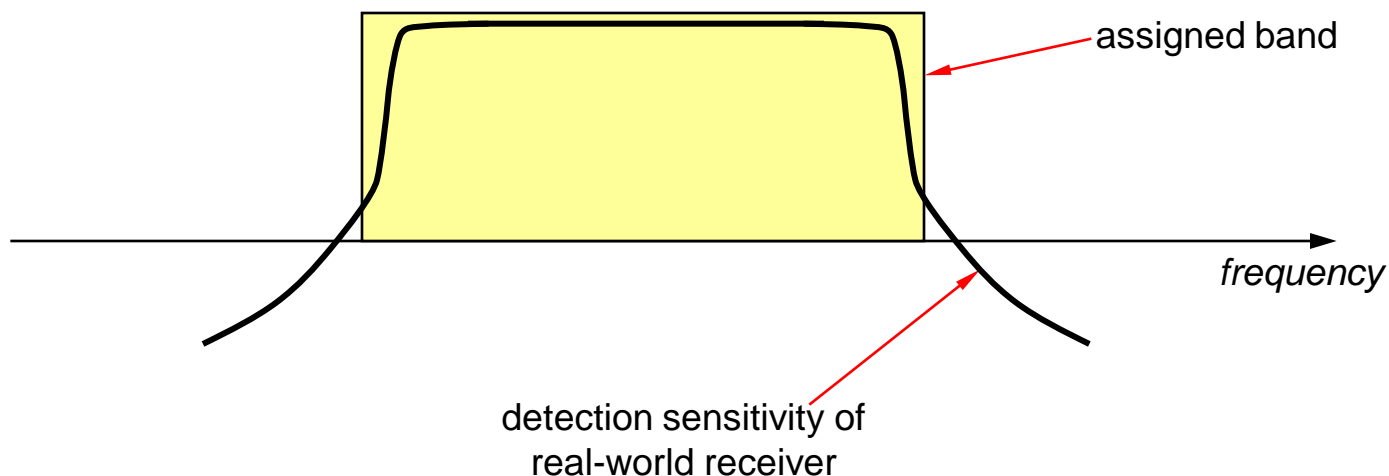


*Theory says:* a perfect band-limited signal would last ad infinitum.

⇒ Tradeoff between Time and Frequency

# Frequency – Real-World Receivers

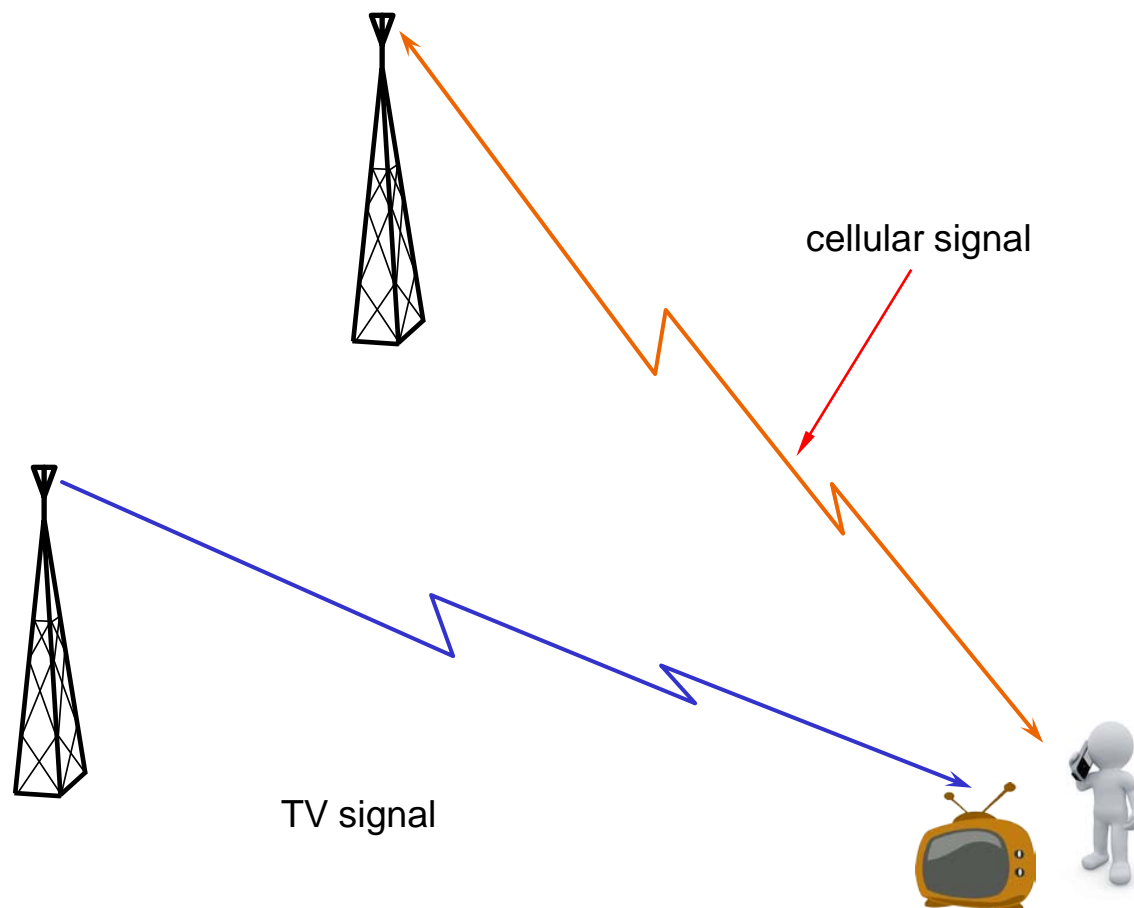
---





# The Near-Far Problem

---



# Conclusion

---

- **Disjoint bands, service areas, transmission times are a simplified view.**
- **In the real world, there are techniques to avoid mutual interference, but they have limitations.**
- **Such limitations must be considered when deciding band allocations.**